LORAN-C CORRECTION TABLES

INTRODUCTION

LORAN-C DESCRIPTION

Basic Principles of Loran-C

Loran-C is a low frequency hyperbolic radionavigation system. The U.S. Department of Transportation has designated Loran-C as the government-provided radionavigation system for the Coastal Confluence Zone (CCZ). To obtain a line of position (LOP) the navigator measures the difference between the time of arrival of a pulse from the master transmitter and a secondary transmitter of a particular chain. The measurement is plotted on a Loran-C chart. The crossing point of two or more LOP's, where each LOP is derived using the same master transmitter but a different secondary transmitter, fixes the receiver in latitude and longtitude (Figure 1). In addition, a Loran-C fix may be resolved by using automatic coordinate converters. No Loran-C chart is necessary. The Radio Technical Commission for Marine Services defines the automatic coordinated converter as: a device which accepts Loran-C time differences (TDs) and converts them to latitude and longitude. This definition also applies to devices that employ a latitude/longitude coordinate system to plot positions on charts and a device which contains both the Loran-C Receiver, which provides the actual position data, and the coordinate converter.

With calibration and the use of additional secondary factors (ASFs) tabulated in this publication, the Loran-C system defines highly accurate fixes. The ASF corrections are applied in three ways: by selecting the correction directly from the table and applying it to the receiver reading; by manually entering a correction into the coordinate converter; by integrating the corrections for a particular area and chain on disc or tape and making the disc or tape a semi-permanent part of the coordinate converter.

Loran-C Chain Calibration

Chain calibration is conducted when a Loran-C chain is established, a secondary is added, and periodically as indicated. The primary purpose of calibration is:

1. To ensure that the Emission Delay (ED) is set to a specified value. ED is defined as the time interval between the master station's transmission and the secondary station's transmission in the same Group Repetition Interval (GRI), both stations using a common time reference. Therefore, the ED is the electrical baseline length (assuming an all seawater path), in microseconds between the master and a secondary, plus the assigned coding delay of the secondary. It is used to compute the Time Difference (TDs) portrayed on Loran-C charts. The ED for each secondary is listed in the Loran-C Data Sheets published by the U.S. Coast Guard.

2. To ensure that each Envelope-to-Cycle Difference (ECD), as received in the hyperbolic service area, causes minimal cycle selection error. ECD is a measure of how much the pulse envelope is phase shifted in relation to the Radio Frequency Carrier. More technically, ECD is the time difference between a point which is 30 μ s after the time origin of the Loran-C envelope ("tag" point) and the standard zero crossing. The standard zero crossing is defined as the closest positive-going zero crossing of the R.F. requency Carrier (on a positive phase coded pulse) to the 30 μ s "tag" point (See Figure 2).

Loran-C users who are interested in a detailed explanation of Loran-C Calibration should contact the U.S. Coast Guard, Washington, D.C. 20593.

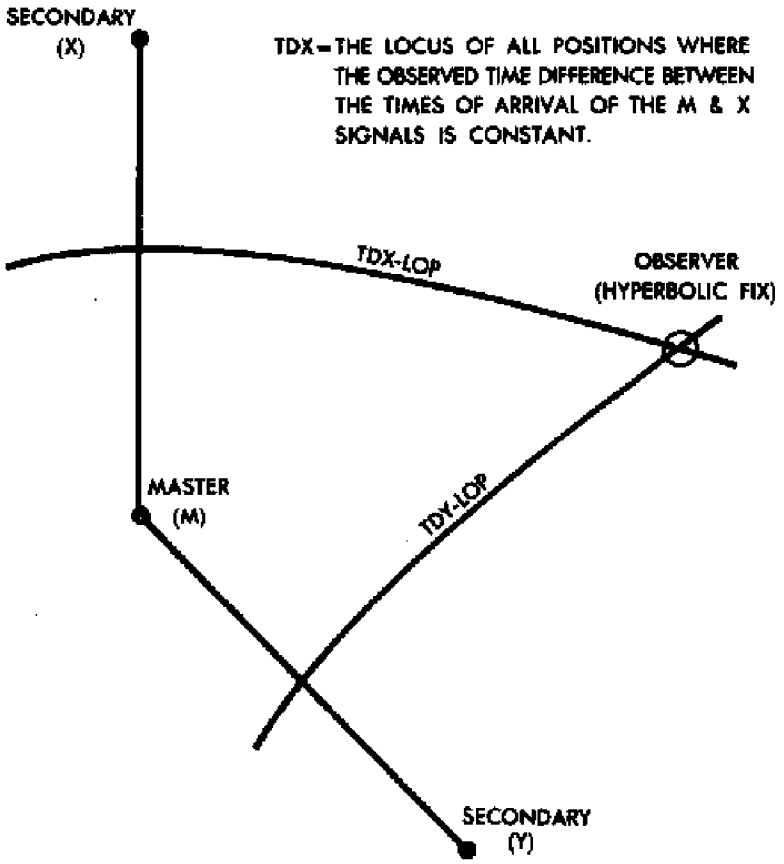
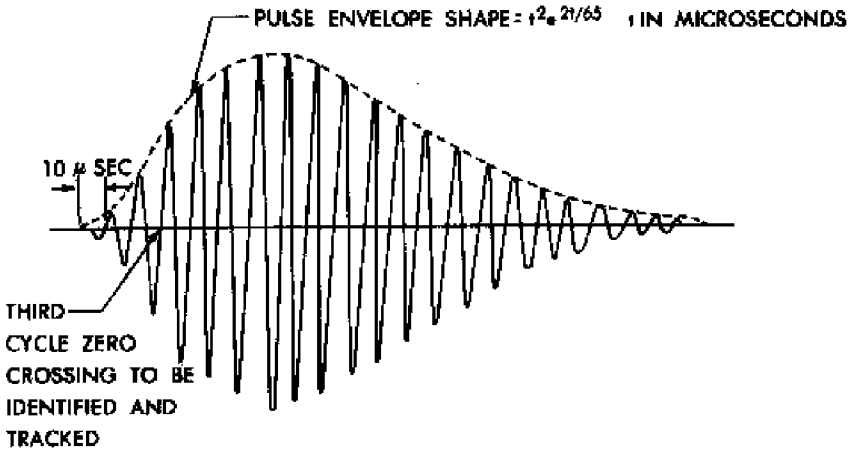
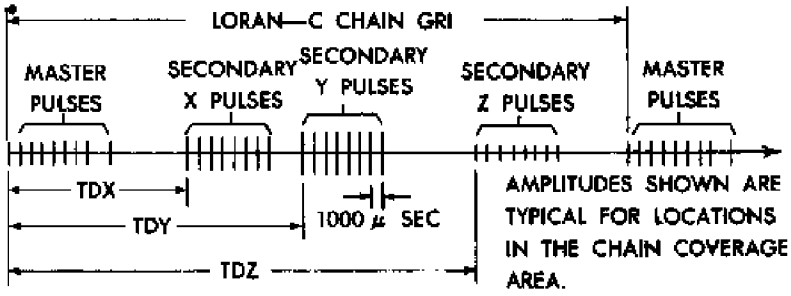


FIGURE 1 HYPERBOLIC FIX GEOMETRY



LORAN—C PULSE



EXAMPLE OF RECEIVED LORAN—C SIGNAL

Figure 2

PHASE CORRECTIONS

The term Phase Velocity is used to describe the leading edge of the Loran-C wave at its point of contact with the earth's surface. This velocity is affected by conductivity (electrical properties of the earth's surface) and atmospheric effects. Consequently, it may be retarded or advanced slightly. If these effects are not considered, fix accuracy is degraded. They are defined as:

1. PRIMARY PHASE FACTOR (PF) -
   A correction to a Loran-C reading due to signal propagation through the atmosphere as opposed to propagation through free space.
   The Index of Refraction is typically 1.000338.

2. SECONDARY PHASE FACTOR (SF) -
   The amount, in microseconds, by which the predicted time difference of a pair of Loran-C signals that travel over all seawater paths differs from that of signals that travel through atmosphere. Constants used in the calculation of this correction are typically:
   - conductivity of seawater = 5 mho/meter
   - permittivity of seawater = 80 e.s.u.
   - vertical lapse rate of the permittivity of the atmosphere = 0.75

3. ADDITIONAL SECONDARY PHASE FACTOR (ASF)
   The amount, in microseconds, by which the time difference of an actual pair of Loran-C signals that travel over terrain of various conductivities differs from that of signals which have been predicted on the basis of travel over all sea water paths.

The constant values of the Primary Phase Factor and the Secondary Phase Factor, listed above, are inputs to the Electronic Navigation Digital Data System's (ENDDS) computer algorithms which compute ASF. Subsequent ENDDS programs compare these theoretically derived ASF with a standard which is ASF survey data collected by the U.S. Coast Guard and the National Ocean Service in the Coastal Confluence Zone. If necessary, adjustments are made.

Receiver readings corrected for ASF enable the navigator to fix his position with ¼ nautical mile accuracy (2 drms) 95% of the time.

TABLE DESCRIPTION

Each table contains a complete chain. A table section is prepared for each station pair (master station and one slave station) in a Loran-C chain. As a rule the limits of the table coverage are determined by the range of the groundwave transmissions for the Loran-C chain, (see chartlets.) Each page of corrections in the table covers an area three degrees in latitude by one degree of longitude, with corrections printed in increments of five minutes of arc. The latitude values are printed in the left hand column of each correction page. The longitude values are printed in the upper rows of the page. Rate designation and page numbers are printed at the top of each correction page.

Pages are numbered from left to right, starting in the upper left corner of the area, (see Page Index, page 1 of each section). Those pages on which the latitude and longitude limits include all land will be omitted and their numbers transferred to the next appropriate page. Those pages where latitude and longitude limits contain both land and sea are included but contain only the area covered by the U.S. Coastal Confluence Zone. Large land bodies and areas outside the CCZ will be represented by blank spaces on the page.

ASF correction values can be either positive or negative. Negative values are indicated by a negative sign preceding the number. The positive values are shown without sign. Areas requiring no correction show a zero value which in some cases is preceded by a negative sign. The negative sign preceding a zero results from the rounding off of a value slightly less than zero and indicates the trend of the correction.

USE OF TABLES

The ASF Correction Tables are published primarily for precision navigators who utilize electronic computers to convert Loran-C time difference to geographic coordinates. This does not preclude application of the tables by navigators using manual plotting methods for Loran-C navigation.

Although the ASF Corrections are generally too small to affect a Loran-C fix plotted on a small scale chart, they can become as large as ±4 microseconds. This offset in feet will be minimal on the baseline, but in other areas of coverage, this offset is appreciable due to expansion of lane width between hyperbolas, (see Page Indexes for gradient data).

The table can be entered directly by using the ship's position determined to the nearest five minutes of arc in latitude and longitude either by dead reckoning or some other means. To find the page with the appropriate correction, the Page Indexes of the table should be utilized. These indexes show the limits and page number of all pages in the table. Each page is three degrees in latitude and one degree in longitude. Enter the Page Index with the ship's position and locate the number of the page on which the desired correction is found. In some cases the ship's position will fall on the page limit in either latitude or longitude or both. These positions are repeated on both pages and either page may be used. The ASF Correction is added algebraically to the time difference for the Loran-C pair. Many users having electronic computers will enter these values directly into the computer. While in the area where the corrections apply, the value will be applied automatically to all sampled time differences for particular pairs. The geographic position determined from the corrected time differences will provide a more precise position.

TABLE LIMITATIONS

Interpolation of this data will not necessarily improve your accuracy since the information is not of a linear nature. The correction nearest the derived latitude and longitude should be applied to the appropriate time difference.

ASF Corrections should be used with cautions for areas within ten nautical miles of land. This area represents an unreliable zone where large variations occur in the magnitude of the correction.

CAUTION

This table is not to be used with a chart that provides a corrected lattice. Charts which portray corrected lattices contain a note to that effect.

EXAMPLE

Loran-C receiver dial readings sampled by the computer are 12153.31 microseconds and 44451.83 microseconds for pairs 9960-W and 9960-Y respectively. From these readings the computer determines a position of 44°15'.1N latitude and 67°25'.4W longitude. Entering the Page Index of Section W with the latitude and longitude nearest to the computed ship's position, the page number containing the derived geographics is found to be 17W, example page VI. Entering page 17W the correction at 44°15'N and 67°25'W is + .5 microseconds. On page 17Y, example page VII, at the same position the correction is + 2.7 microseconds.

The ASF corrections are applied to the dial readings as follows:

WTD	12153.31	YTD	44451.83
ASF CORRECTION	+ 1.5	ASF CORRECTION	+ 2.7
CORRECTED TD	12154.81	CORRECTED TD	44454.53

The corrected dial readings are used to recompute a new latitude and longitude for the Loran-C fix. The new position is 44°15'.4N latitude and 67°26'.4W.

EXAMPLE 1

9960-M 17M

LATITUDE NORTH	LONGITUDE WEST												
	68° 0′	55	50	45	40	35	30	25	20	15	10	5	67° 0′
45° 0′													
55													
50			LAND										2.0
45												1.7	1.6
40									1.7	1.7	1.6	1.6	1.6
35							1.7	1.6	1.6	1.6	1.5	1.5	1.5
30					1.6	1.5	1.5	1.6	1.6	1.6	1.5	1.5	1.5
25													
20	1.6	1.5	1.6	1.6	1.5	1.4	1.5	1.5	1.5	1.5	1.5	1.5	1.5
15	1.6	1.5	1.5	1.5	1.5	1.5	1.5	(1.5)	1.5	1.5	1.5	1.4	1.4
10	1.5	1.4	1.5	1.5	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.3
5	1.4	1.4	1.5	1.4	1.4	1.4	1.3	1.3	1.3	1.3	1.3	1.3	
44° 0′	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.2	1.3	1.3			
55	1.3	1.3	1.2	1.3	1.3	1.3	1.3	1.3	1.2				
50	1.3	1.3	1.3	1.3	1.3	1.3	1.3						
45	1.3	1.3	1.2	1.3	1.3	1.3							
40	1.2	1.2	1.3	1.3	1.3								
35	1.3	1.2	1.3										
30	1.3	1.3	1.3										
25	1.2	1.3	1.3						OUTSIDE CCZ				
20	1.2	1.3	1.3	1.3									
15	1.2	1.3	1.3	1.3	1.3								
10	1.2	1.2	1.3	1.3	1.3								
5	1.2	1.2	1.2	1.3	1.3	1.3							
43° 0′	1.2	1.2	1.2	1.2	1.3	1.3	1.3						
55	1.2	1.2	1.2	1.2	1.3	1.3	1.3						
50	1.2	1.2	1.2	1.2	1.2	1.3	1.3	1.3					
45	1.2	1.2	1.2	1.2	1.2	1.2	1.3	1.3	1.3				
40	1.2	1.2	1.2	1.2	1.2	1.2	1.3	1.3	1.3	1.3			
35	1.2	1.2	1.2	1.2	1.2	1.2	1.3	1.3	1.3	1.3			
30	1.3	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.3	1.3			
25	1.2	1.2	1.2	1.2	1.2	1.3	1.3	1.3	1.2	1.3	1.3	1.3	1.3
20	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.3	1.2	1.2	1.2	1.2	1.3
15	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.3	1.2
10	1.2	1.1	1.2	1.2	1.2	1.2	1.2	1.3	1.2	1.2	1.2	1.3	1.2
5	1.2	1.1	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2
42° 0′	1.1	1.1	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2

EXAMPLE 2

9960-Y

LONGITUDE WEST

LATITUDE NORTH	68° 0′	55	50	45	40	35	30	25	20	15	10	5	67° 0′
45° 0′													
55													
50													3.4
45				LAND								3.1	3.0
40									3.0	3.1	3.0	2.9	2.9
35							2.9	2.9	2.9	2.9	2.8	2.8	2.8
30													
25					2.7	2.8	2.8	2.8	2.8	2.8	2.8	2.7	2.7
20	2.8	2.7	2.7	2.7	2.7	2.7	2.7	2.8	2.7	2.7	2.6	2.7	2.6
15	2.7	2.6	2.6	2.7	2.8	2.7	2.7	2.7	2.7	2.6	2.6	2.6	2.6
10	2.7	2.6	2.6	2.7	2.7	2.6	2.6	2.5	2.5	2.6	2.6	2.6	2.6
5	2.6	2.6	2.6	2.6	2.5	2.5	2.4	2.4	2.4	2.5	2.5	2.5	
44° 0′	2.5	2.5	2.5	2.5	2.4	2.4	2.4	2.3	2.4	2.4			
55	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4				
50	2.4	2.4	2.4	2.4	2.4	2.4	2.4						
45	2.4	2.4	2.3	2.4	2.4	2.4							
40	2.3	2.3	2.3	2.4	2.4								
35	2.4	2.4	2.4										
30	2.4	2.4	2.4						OUTSIDE CCZ				
25	2.4	2.4	2.4										
20	2.4	2.4	2.4	2.4									
15	2.4	2.4	2.4	2.4	2.4								
10	2.4	2.4	2.4	2.4	2.4								
5	2.4	2.4	2.4	2.4	2.4	2.4							
43° 0′	2.4	2.4	2.4	2.4	2.4	2.4	2.4						
55	2.4	2.4	2.4	2.4	2.4	2.4	2.4						
50	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4					
45	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4				
40	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4			
35	2.5	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4			
30	2.5	2.5	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4			
25	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.5
20	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4
15	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4
10	2.4	2.3	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4
5	2.4	2.3	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4
42° 0′	2.4	2.3	2.3	2.4	2.3	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4